THE E-WASTE STREAM IN THE WORLD-SYSTEM

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Globalization and sustainability are contradictory tendencies in the current world-system. Consider the fact that transnational corporations transfer some of the core's wastes to the peripheral zones of the world-system. Such exports reduce sustainability and put humans and the environment in recipient countries at substantial risk. The specific case of e-waste exports to Guiyu, China is discussed. The discussion proceeds in several steps. The nature of the e-waste trade is first examined. Political-economic forces that have increased e-waste trafficking to China are outlined. The extent to which this trade has negative health, environmental, and social consequences are outlined and the neo-liberal contention that such exports are economically beneficial to the core and periphery is critically examined. Policies proposed as solutions to the problem are critically reviewed.

Keywords: *e-waste, recycling, hazardous wastes, environmental justice, sustainability, world-systems theory, ecological unequal exchange, capital accumulation.*

Introduction

The editors of *The Economist* (2007: 14) magazine made several observations about globalization recently that are worth quoting because they raise important questions about environmental justice and sustainability in an increasingly globalized world. Sounding a bit like Marie Antoinette, the editors wrote:

> …the best way of recycling waste may well be to sell it, often to emerging markets. That is controversial, because of the suspicion that waste will be dumped, or that workers and the environment will be poorly protected. Yet recycling has economics of scale and the transport can be virtually free-filling up the containers that came to the West full of clothes and electronics and would otherwise return empty to China. What is more, those who are prepared to buy waste are likely to make good use of it.

Despite the internal consistency of their market logic and celebration of the current global system, globalization and environmental justice as well as sustainability can be seen as contradictory tendencies in the current world-system. Consider, for instance, the fact that centrality in the world-system allows some countries to export their environmental harms to other countries (Frey 1998a, 1998b, 2006a, 2006b, 2012). Such exports increase environmental injustice and reduce sustainability by putting humans and the environment in recipient countries at substantial risk. The specific case of e-waste exports to Guiyu, China is discussed in light of the contradictory tendencies mentioned.

The discussion proceeds in several steps. Environmental justice and sustainability in the world-system are first examined. This is followed by a discussion of the e-waste trade in the world-system. The extent to which this trade has negative health, safety, and environmental consequences in Guiyu, China is outlined and the neo-liberal contention that such exports are economically beneficial to the core and periphery is critically examined. Policies proposed as solutions to the problem of e-waste traffic in Guiyu and the world-system are critically reviewed. The paper concludes with an assessment of the likelihood that existing 'counter-hegemonic' globalization forces will overcome the tensions between globalization and environmental justice and sustainability.

Environmental Justice and Sustainability in the World-System

The world-system is a global economic system in which goods and services are produced for profit and the process of capital accumulation must be continuous if the system is to survive (see especially Wallerstein [2004] for the origins and nature of the world-system perspective and Harvey [2010] for a recent discussion of continuous capital accumulation under capitalist relations). Proponents of the perspective conceptualize the world-system as a three-tiered system, consisting of a core, semi-periphery, and periphery.

The world-system is an open system that can be understood not only in 'economic' terms but also in 'physical or metabolic' terms: entry of energy and materials and exit of dissipated energy and material waste (Frey 1998a; Hornborg 2011; Martinez-Alier 2009; Rice 2007, 2009). In fact, the world-system and globalization itself can be described or understood in terms of a process of 'ecological unequal exchange' (*e.g.,* Hornborg 2011; Rice 2007, 2009; or a process of 'accumulation by extraction and contamination'). Frey (2006a) has described the process of ecological unequal exchange in the following terms:

- **Wealth** (in the form of materials, energy, genetic diversity, and food and fiber) flows from the resource rich countries of the periphery to the industrialized countries of the core, resulting often in problems of resource depletion/degradation and pollution in the peripheral zones or the 'resource extraction frontiers'.
- The core displaces **anti-wealth** (entropy broadly defined) or appropriates carrying capacity or waste assimilation by transporting it to the global sinks or to the sinks of the periphery in the form of hazardous exports. In other words, global sinks and the peripheral zones of the world-system are essentially 'waste-disposal frontiers'.

This paper focuses on the transfer of hazards to the peripheral zones of the world-system, whether hazardous products, production processes, or wastes, with a focus on e-waste. Such hazards damage the environment and adversely affect human health through environmental and occupational exposure. Peripheral countries are particularly vulnerable to the risks posed by such hazards for several reasons: limited public awareness; a young, poorly trained, and unhealthy workforce; politically unresponsive state agencies; and inadequate risk assessment and management capabilities and infrastructure (*e.g.,* Frey 2006a).

The core (consumers, states, and capital in various countries) benefits from the transfer of hazards to the periphery while the periphery bears the costs associated with such exports. Environmental justice and sustainability are enhanced in the core because environmental harms are displaced to the periphery, while such export practices increase environmental injustice and reduce sustainability in the periphery. Risks associated with hazardous exports or environmental harms are distributed in an unequal fashion within the periphery: some groups (especially the state and capital) are able to capture the benefits while others (those marginalized by gender, age, class, race/ethnicity, and geo-spatial location) bear the costs (see Frey 2006a).

E-Waste in the World-System

Nature and Scope of E-Waste

E-waste consists of discarded computers, cell phones, televisions, and other electrical and electronic products (see Widmer *et al.* [2005] for a review of existing definitions of e-waste). This waste is a byproduct of the information and communication technology-infrastructure underlying the world system's social metabolism. Globalization is dependent (or 'symbiotic', to use Pellow's [2007: 185] term) on information and communication technology, most notably the computer. It is the computer in conjunction with the internet (and the global transport system) that facilitates the transport of wealth to the core and anti-wealth to the periphery, whether it is the movement of bauxite and iron ore from Brazil by large ocean going vessels (Bunker and Ciccantell 2005) or the recycling, incineration, and/or disposal of e-waste in China.

E-waste is growing more rapidly than other waste streams because the consumption of electronic products is growing at an astonishing pace. Increased consumption of electronic products is due to the constant development of new electronic products, planned obsolescence, and falling prices throughout the developed world. In 1975, for example, there was one computer per 1,000 population in the US, but in 2010 the number was over 800 computers per 1,000 population (United Nations 2010). And it is expected that growth of computers will continue in the core and be overtaken by the developing countries in the next fifteen to twenty years (Yu *et al.* 2010a).

Anywhere from 30 to 50 million tons of e-waste are discarded each year in the world-system (according to the Basel Action Network and Silicon Valley Toxics Coalition [2002] and the United Nations Environment Programme [2009]). Every year, hundreds of thousands of old computers and mobile phones are dumped in landfills or burned in smelters. Thousands more are exported, often illegally, from Europe, the US, Japan and other industrialized countries, to countries in Africa and Asia (Bhutta *et al.* 2010). Recipient countries include Bangladesh, China, India, Malaysia, Pakistan, the Philippines, and Vietnam in Asia and Ghana and Nigeria in West Africa. In fact, it is estimated that upwards of 80 per cent of the US's e-waste is exported to these countries with 90 per cent of the waste going to China (Grossman 2006: ch. 7).

E-waste follows a path of least resistance: it flows from the highly regulated core countries to low wage countries with limited health and environmental regulation. It is exported to countries for inexpensive, labor intensive recycling, incineration, and/or disposal (Basel Action Network and Silicon Valley Toxics Coalition 2002; Nnorom, Osibanjo, and Ogwvegbul 2011; Tsydenova and Bengtsson 2011). Valuable materials extracted from computers include copper, lead, plastics, steel, and glass. The state and capital in China (and many peripheral countries) want the 'recycling' industry for economic reasons, including the high demand for used parts and the increasing demand for materials to supply the growing manufacturing sector.

Guiyu Township in Guangdong Province is one of the major destinations for much of the e-waste entering China and it the largest e-waste recycling site in the world-system. (Taizhou city is the second largest site in China and it is located south of

Shanghai.) Guiyu is 100 miles northwest of Guanghou and has a population of approximately 200,000 people in seventeen villages (the four main villages are Huamei, Longgang, Xianpeng, and Beilin) (see *Appendix* Fig. 1 for the location of Guiyu). Once a rice producing area, Guiyu became an e-waste recycling center in the early 1990s, though its residents have a long history of waste collection stretching back to the early 20th century when residents would collect duck feathers, scrap metal, and pig bones for sale. Guiyu is now home to an estimated 150,000 e-waste workers (including children, as well as commuters from nearby areas) engaged in e-waste recycling (see *Appendix* Fig. 2). Much of the e-waste recycling that takes place in Guiyu consists of the dismantling of computers and related accessories imported from the US, Japan, Canada, South Korea, Europe, and Taiwan (Basel Action Network and Silicon Valley Toxics Coalition 2002; Grossman 2006: ch. 7; Sepulveda *et al.* 2010).

Steps in Dismantling Computers

Brokers based in Hong Kong and Taiwan sell the e-waste to recyclers through e-waste dealers in China who pay anywhere from 400 to 500 dollars or more per ton for computers (Grossman 2006: ch. 7). The cost depends on the composition of the e-waste (whether circuit boards, monitors, printers, or the like) and profit margins. Several steps are followed once the e-waste reaches its port of destination in Hong Kong or Shantou, China (see Basel Action Network and Silicon Valley Toxics Coalition 2002; Grossman 2006: ch. 7; Tsydenova and Bengtsson 2011: 51–55).

- Computers are trucked in after they are unloaded from container ships in their port of destination.
- Cathode ray tubes are broken with hammers, exposing the toxic phosphor dust inside. The copper yokes are removed and sold to metal dealers (see *Appendix* Fig. 3).
- Circuit boards are cooked in woks over open charcoal fires to melt the lead solder, releasing toxic lead fumes. The lead solder is collected for metal dealers.
- Large pieces of plastic are melted into thin rods and cut into small granules and sold to factories that make low quality plastic goods.
- Wires are stripped by hand or burned in open piles to melt the plastics to get at the copper and other metals inside (see *Appendix* Fig. 4).
- Acid baths are used to extract certain materials from microchips such as gold. Nitric and hydrochloric acids are used to release gold from plastic and other commodities and the acids are dumped into the local environment.
- Plastic casings are burned, creating dioxins and furans – which are extremely hazardous to human health.
- Unwanted leaded glass and other materials are dumped in ditches.
- Acids and dissolved heavy metals are dumped directly into local waterways.

Buyers from local factories and outside the area purchase the metals such as copper, gold, aluminum, steel, and other commodities and sell them locally and nationally.

Health and Environmental Risks Associated with Computer Dismantling

The average desktop computer contains valuable recyclable and hazardous materials. Alumnum, copper, gold, steel, and platinum, as well as the more toxic lead are the most valuable materials (*e.g.,* Williams *et al.* 2008: 6447, Table 1). Hazardous materials include heavy metals, brominated flame retardants, and many other toxic materials; lead and cadmium and mercury in circuit boards; lead oxide in CRTs; mercury in switches and flat screen monitors; cadmium in computer batteries; and persistent organic pollutants (dioxins, PVCs, and PAHs) in plastics (Nnorom *et al.* 2011; Tsydenova and Bengtsson 2011).

As noted above, materials are extracted in an unsafe fashion. Recycling practices release toxins from hazadous materials and generate new ones. Open air incineration is used to recover copper in wiring and acid baths are used to extract metals such as copper and gold. Waste is dumped in irrigation canals and other waterways, including the nearby Lianjiang River (Sepulveda *et al.* 2010; Tsydenova and Bengtsson 2011). Working conditions are primitive and unsafe, and workers are exposed to toxic materials but little safety equipment is available. Labor conditions are grave for the workers: they work six day work weeks of twelve hours duration per day for limited pay and they have few rights. Child labor is quite common (Basel Action Network and Silicon Valley Toxics Coalition 2002; Grossman 2006: ch. 7).

Available research indicates that human health and the environment are under assualt in Guiyu (see the excellent reviews of the extant literature by Sepulveda *et al.* 2010 and Tsydenova and Bengtsson 2011). The air, soil, and water of Guiyu are contaminated with a range of toxic materials, including lead, cadmium, PCBs, benzene, and so on (Bi *et al.* 2010; Tsydenova and Bengtsson 2011). A study released in 2007 (Huo *et al.* 2007) found that a majority of the children sampled in Guiyu had blood levels of lead and cadmium many times higher than limits set by the US Centers for Disease Control and Prevention. A recent study (Yang *et al.* 2011) undertaken at the other major e-waste recycling site in China, Taizhou, indicates that air samples from the area contain toxic particulate matter that can induce human DNA damage. Exposure to these and related materials are extremely hazardous to human health and represent significant risks to other species, as well as the larger environment and surrounding human communities.

Evaluating the Costs and Benefits

Are the costs associated with the displacement of e-waste recycling to Guiyu offset by the economic and other benefits as proponents of neoliberalism (Grossman and Krueger 1993, 1995) and some ecological modernization theorists (Mol 2001) would suggest? After all, e-waste recycling employs at least 150,000 poor workers desperate for jobs in Guiyu. The materials and parts recovered are recycled and used domestically which reduces dependence on outside sources, reduces pollution associated with mining, provides needed capital for the economy, and reduces energy use and carbon dioxide emissions. In addition, import duties on some of the incoming goods provide a revenue stream for government (see Williams *et al.* 2008: 6449–6450 for a discussion of the benefits of computer exports).

Answering the question raised above as noted elsewhere (Frey 2006a) is problematic because it is difficult to identify, estimate, and value the costs and benefits (especially the costs) associated with hazards in monetary terms (see, *e.g.,* Frey, McCormick, and Rosa 2007; Williams *et al.* 2008). Despite suggestions and efforts to the contrary (*e.g.,* Logan 1991), there is no widely accepted factual or methodological basis for identifying, estimating, and valuing the costs and benefits associated with the flow of core hazards to the periphery. Even if the consequences of hazardous exports could be meaningfully identified and estimated, there remains the question of valuing them in monetary terms. Economists typically look to the marketplace for such a valuation, but adverse health, safety, environmental, and socio-economic consequences are not traded in the marketplace. Efforts have been made to deal with this problem by using either expert judgment or public preferences, but such techniques are deeply flawed (see Dietz, Frey, and Rosa 2002; Foster 2002a).

When he was Chief Economist of the World Bank, Lawrence Summers (1991) made the argument much like the editors of *The Economist* mentioned above, that displacing environmental harms to peripheral areas makes economic sense. He wrote in a World Bank memo: 'I think the economic logic behind dumping a load of toxic waste in the lowest-wage country is impeccable and we should face up to that'. Environmental harms should be sent to poor areas because 'measurements of the costs of health impairing pollution depend on the forgone earnings from increased morbidity and mortality. From this point of view a given amount of health impairing pollution should be done in the country with the lowest cost, which will be the country with the lowest wages'.

As noted elsewhere (Foster 2002b; Frey 2006a; Puckett 2006), such reasoning undervalues nature and assumes that human life in the periphery is worth much less than in the core because of wage differentials. Although most costs occur in the periphery and most benefits are captured by the core and elites located in the periphery, the costs to the periphery are deemed acceptable because life is defined as worth so little. In sum, it can be argued convincingly that the costs associated with the transfer of e-waste to Guiyu, China (and elsewhere, for that matter) outweigh the benefits.

What is to be Done? And Who should Do It?

The Chinese government banned imports of toxic e-waste in 2002 and has created additional regulations since then (as recently as January 1, 2011 [Moxley 2011]; see also Yu *et al.* 2010a for a comprehensive review), but the e-waste continues to flow into the country and thousands of Chinese women continue to cook the core's circuit boards over charcoal burners and the blood lead levels of children remain high. This is a result of lax enforcement of regulations due to bribes and corruption. In turn, local government officials are evaluated by the central government in terms of overall economic growth in their areas, so there is a strong incentive for officials to protect e-waste activities since they contribute to the economic growth of the area. And, of course, China's growth machine requires large material inputs to sustain it and e-waste recycling is an important source for these materials (Grossman 2006; Yu *et al.* 2010b: 992–994, 999).

A number of actors have emerged to challenge e-waste recycling in China. These include Chinese government officials and Chinese NGOs. Pan Yue, Vice Minister of the Ministry of Environmental Protection (CMEP) of the People's Republic of China, has been an unwavering supporter of the environment at all levels (Byrnes 2006). Pan has been very active in promoting partnerships between CMEP and various Chinese environmental NGOs. It is increasingly clear that China (and other developing countries such as India) are going to be confronted with drastic increases in e-waste as domestic computer consumption increases in the next several decades which will further compound the e-waste problem in China and elsewhere (see Yu *et al.* 2010a for estimates of growth in computer consumption by different regions in the world-system).

What is being done to challenge e-waste exports to China and elsewhere in the world-system? The Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal (1989) is a multilateral agreement that was enacted in 1989 under the auspices of the United Nations Environment Programme (and its subsequent amendment to ban e-waste export in 1995 which has yet to be ratified).

The Convention, signed by 170 countries, requires that a country can only ship hazardous wastes if it has received written consent from the recipient country. The Convention has been ineffective in stopping the trade for several interrelated reasons. The US, one of the world's largest e-waste exporters, has not signed the bill and thus the effectiveness of the Convention has been undercut. The Convention has been ineffective because illegal shipments of wastes are pervasive and a general lack of implementation at the border areas in China.

The United Nations Environment Programme (2005, 2009) and international NGOs, including Greenpeace International and Greenpeace China, Silicon Valley Toxics Coalition, the Basel Action Network, and others have been monitoring and studying export flows and actual conditions in and around the recycling centers in China and elsewhere (Basel Action Network and Silicon Valley Toxics Coalition, 2002). The Basel Action Network has been particularly active in pressuring state authorities in the developed countries to enforce higher standards (see Puckett 2006; www.ban.org). The Basel Action Network, other international organizations, and analysts have made a number of specific recommendations for dealing with the e-waste problem (see, *e.g.,* Grossman 2006: ch. 7; Nnorom *et al.* 2011; Pellow 2007: 203–224; Smith, Sonnenfeld, and Pellow 2006; United Nations Environment Programme 2005, 2009; Yu *et al.* 2010b). A sampling of these recommendations are listed below:

- A fully implemented global regime should be developed to regulate the movement of computer waste.
- The next generation of computers should be constructed to reduce health, safety, and environmental impacts at the time of decommissioning and increase capacity to upgrade computers over time.
- End-of-life electronics and greener design using fewer toxic materials and increased capacity for upgrades.
- Extended Producer Responsibility (EPR) as a new paradigm in waste management.

The European Union's Directive on Waste from Electrical and Electronic Equipment (WEEE), along with the RoHs Directive, were enacted into law in February 2003 and came into force in 2004. The Directives require manufacturers and importers in the European Union countries to take back their products from consumers and ensure safe waste disposal or safe recycling-reuse. Heavy metals (lead, mercury, cadmium, and chromium) and flame retardants (polybrominated biphenyls and polybrominated biphenyl ethers) were to be replaced with safer materials. The directives have not been fully implemented (European Commission 2002; Geiser and Tickner 2006).

After years of failure to address the issue of e-waste (see Stephenson 2008), the US has moved forward in several areas. On November 15, 2010, President Obama issued a presidential proclamation on e-waste recycling and the creation of an Interagency Task Force of Agencies within the federal government ‘to prepare a national strategy for responsible electronics stewardship, including improvements to Federal procedures for managing electronic products’. He indicated he wanted the Federal Government to lead (Nevison 2011). The report of the Task Force was released in July 2011. The Task Force identified four major goals, one of which centers on reducing ‘harm from US exports of e-waste and improve safe handling of used electronics in developing countries’ through five specific actions (Interagency Task Force … 2011: 2–3).

- Improve information on trade flows and handling of used electronics, and share data with Federal and international agencies, within the limits of existing legal authorities.
- Provide technical assistance and establish partnerships with developing countries to better manage used electronics.
- Work with exporters to explore how to incentivize and promote the safe handling of remanufactured, recycled, and used electronics at home and abroad.
- Propose regulatory changes to improve compliance with the existing regulation that governs the export of cathode ray tubes from used computer monitors and televisions that are destined for reuse and recycling.
- Support ratification of the Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal.

Two Democratic Representatives (Gene Green of Texas and Mike Thompson of California) introduced the Responsible Electronic Recycling Act in the US House of Representatives on June 22, 2011. The bill would ban the export of certain restricted electronic waste exports to developing countries. 'The bill aims to stop U.S. companies from dumping dangerous old electronics on countries where they are broken apart or burned by workers using few safety precautions', said Texas Representative Gene Green. It is reported that several computer manufacturers support the bill (Miclat 2011).

The Basel Action Network adopted a certification program in April 2010 called the e-Stewards Standard for Reasonable Recycling and Reuse of Electronic Equipment. The program referred to as e-Stewards Certification was established to facilitate responsible disposal of e-waste materials. Basel Action Network announced on July 5, 2011 that Intercon Solutions (a Chicago Heights, Illinois, electronics recycler) would be the first company denied BAN's e-Stewards certification, which aims to recognize e-waste recyclers operating responsibly.[1]

Concluding Remarks

Counter-hegemonic globalization or 'globalization from below' in the form of transnational networks of NGOs remains one of the most viable means for curbing the adverse consequences associated with the transfer of hazardous processes to the periphery (see Frey 2006a). Globalization from below may help reduce or mitigate the worst abuses associated with the displacement of computer recycling and other environmental harms to the periphery as suggested by the concrete actions that have occurred in China, the EU, and the US noted above (see Yu *et al.* 2010a, 2010b and Williams *et al.* 2008 for a very insightful discussion of why the existing policies noted above are unlikely to solve the e-waste problem in China and elsewhere). Stopping the core's appropriation of the periphery's carrying capacity is another matter, for this process is embedded in the structure of the current world-system. In other words, the process of 'ecological unequal exchange' between the core and periphery is necessary for continued capital accumulation in the core. And it will be some time before environmental justice and sustainability are realized in the peripheral zones of the world-system because of the contradictory tendencies between accumulation in the core and the role of the periphery as resource extraction frontier and waste disposal frontier. To put it another way, the 'metabolic rift' (Foster, Clark, and York 2010) between the core and periphery is made invisible by globalization and the attendant market ideology espoused by proponents of the neoliberal perspective, including the editors of *The Economist* cited at the beginning of the paper.

NOTE

[1] See www.ban.org; www.e-stewards.org/certification-overview.

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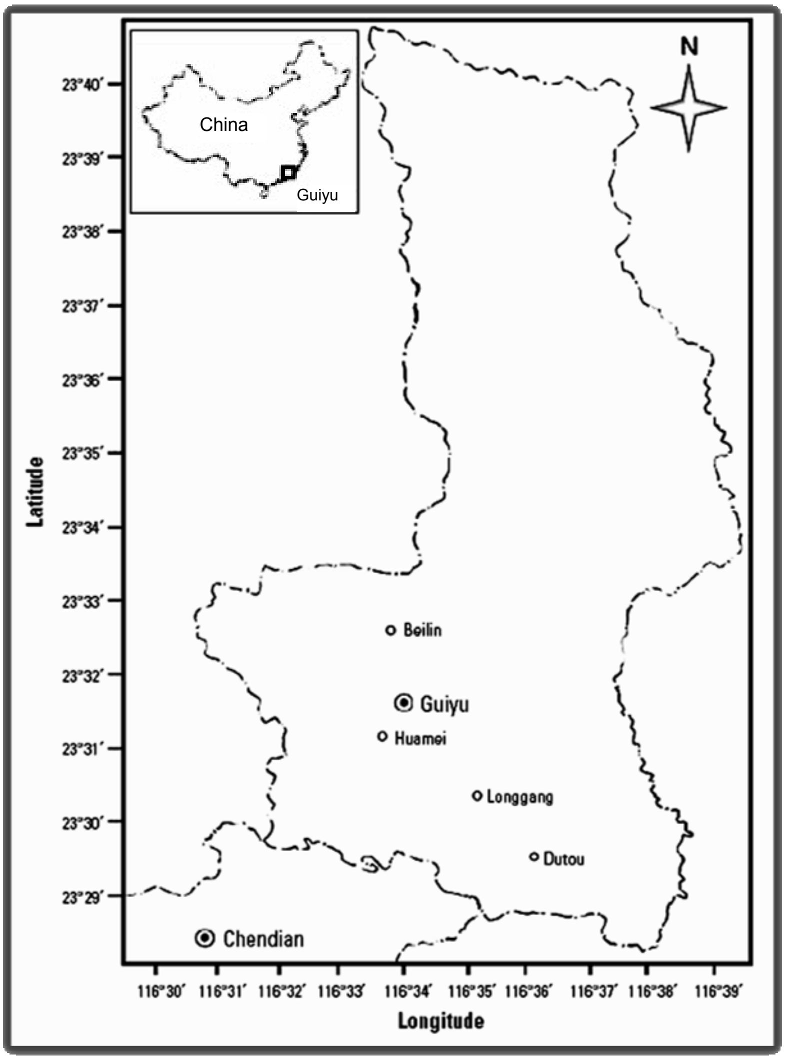

Fig. 1. Location of Guiyu, China

Source: Google.

Fig. 2. Child on e-waste in South China

Source: Basel Action Network.

Fig. 3. Dismantling computers in South China

Source: Basel Action Network.

Fig. 4. Stripping Computer Wires in South China

Source: Basel Action Network.